This print-out should have 27 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 10.0 points

Arrange the compounds

I)	CuS	$K_{sp} = 1.3 \times 10^{-36}$
II)	$PbCl_2$	$K_{sp} = 1.6 \times 10^{-5}$
III)	FeS	$K_{sp} = 6.3 \times 10^{-18}$
IV)	Hg_2Cl_2	$K_{sp} = 2.6 \times 10^{-18}$
V)	Cu_2S	$K_{sp} = 2.0 \times 10^{-47}$

in increasing order of molar solubility.

1. I, V, III, IV, II **correct**

2. I, II, III, IV, V

3. II, III, IV, I, V

4. II, IV, III, V, I

5. V, I, IV, III, II

Explanation:

002 10.0 points

What is the molar solubility of $CaCO_3$ in water? $K_{sp} = 8.7 \times 10^{-9}$.

Correct answer: 9.32738×10^{-5} mol/L.

Explanation:

The solubility equilibrium is

$$CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$$
$$K_{sp} = [Ca^{2+}]\,[CO_3^{2-}] = S \cdot S$$
$$8.7 \times 10^{-9} = S^2$$
$$S = 9.32738 \times 10^{-5} \text{ mol/L}$$

003 10.0 points

Determine if a precipitate will form when 0.96 g Na_2CO_3 is combined with 0.2 g $BaBr_2$ in a 10 L solution ($BaCO_3 K_{sp} = 2.8 \times 10^{-9}$).

1. NaBr does not precipitate

2. NaBr precipitates **correct**

Explanation:

$V_{Na_2CO_3} = 0.96$ g/10 L $\quad V_{BaBr_2} = 0.2$ g/10 L

$K_{sp} = 2.8 \times 10^{-9}$

$$Na_2CO_3 + BaBr_2(aq) \longrightarrow 2\,NaBr(aq) + BaCO_3(s)$$

$$BaCO_3s) \rightleftharpoons Ba^{2+}(aq) + CO_3^{2-}(aq)$$
$$K_{sp} = [Na^+]\,[Br^-] = 2.8 \times 10^{-9}$$

$$\left(\frac{0.96 \text{ g } Na_2CO_3}{10 \text{ L}}\right)\left(\frac{1 \text{ mol } CO_3^{2-}}{105.96 \text{ g } Na_2CO_3}\right) = 0.001812 \text{ mol/L } {CO_3}^{2-}$$

$$\left(\frac{0.2 \text{ g } BaBr_2}{10 \text{ L}}\right)\left(\frac{2 \text{ mol } Br^-}{297.13 \text{ g } BaBr_2}\right) = 0.000134621 \text{ mol/L } Br^-$$

$$[Ba^{2+}]\,[COI_3^{2-}] = (0.001812 \text{ mol/L}) \times (0.000134621 \text{ mol/L}) = 2.43934 \times 10^{-7} > K_{sp}$$

$BaCO_3$ precipitates.

004 10.0 points

If 2.5 g of solid $Fe(NO_3)_3$ is added to 100 mL of a 1×10^{-20} M NaOH solution, will a precipitate form?

1. $Fe(NO_3)_3$ precipitates.

2. $Fe(NO_3)_3$ does not precipitate. **correct**

Explanation:

solubility of $Fe(NO_3)_3 = 2.5$ g/100 mL H_2O

$m_{Fe(NO_3)_2} = 2.5$ g $\qquad [NaOH] = 1 \times 10^{-20}$ M

$K_{sp} = 4 \times 10^{-38}$

$$Fe(NO_3)_3 + NaOH \longrightarrow Fe(OH)_3 + NaNO_3$$

$$Fe(OH)_3(s) \rightleftharpoons Fe^{3+}(aq) + 3\,OH^-(aq)$$
$$K_{sp} = [Fe^{3+}]\,[OH^-]^3 = 4 \times 10^{-38}$$

$$\left(2.5 \text{ g } Fe(NO_3)_3\right)\left(\frac{1 \text{ mol } Fe(NO_3)_3}{241.79 \text{ g } Fe(NO_3)_3}\right) = 1.03396 \times 10^{-2} \text{ mol } Fe(NO_3)_3 = 1.03396 \times 10^{-2} \text{ mol } Fe^{3+}$$

$$\left(\frac{1.03396 \times 10^{-2}\text{ mol Fe}^{3+}}{100\text{ mL}}\right)\left(\frac{1000\text{ mL}}{\text{L}}\right) = 1.03396 \times 10^{-1}\text{ mol/L Fe}^{3+}$$

$$[\text{NaOH}] = 1 \times 10^{-20}\text{ M} = [\text{OH}^-]$$

$$\begin{aligned}[\text{Fe}^{3+}]\,[\text{OH}^-]^3 &= (1.03396 \times 10^{-1}\text{ mol/L}) \\ &\quad \times (1 \times 10^{-20}\text{ M})^3 \\ &= 1.03396 \times 10^{-61} < K_{\text{sp}}\end{aligned}$$

$Fe(OH)_3$ does not precipitate.

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005 10.0 points

The K_{sp} for mercury(I) iodide is 1.2×10^{-28}. What is the solubility of mercury(I) iodide?

1. 1.1×10^{-14}

2. 5.2×10^{-8}

3. 3.1×10^{-10} **correct**

4. 3.9×10^{-10}

Explanation:

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006 10.0 points

A solution has $[CO_3^{2-}] = 2 \times 10^{-6}$ and $[Co^{2+}] = 1 \times 10^{-5}$. Will a precipate of $CoCO_3$ form? K_{sp} for $CoCO_3 = 8 \times 10^{-13}$.

1. Yes, because Q is greater than K_{sp}. **correct**

2. No, because Q is greater than K_{sp}.

3. No, because K_{sp} is greater than Q.

4. Yes, because K_{sp} is greater than Q.

Explanation:

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007 10.0 points

K_{sp} for ZnS is 1.1×10^{-21}. At what S^{2-} concentration will ZnS precipitate for a 0.20 M solution of $Zn(NO_3)_2$? $Zn(NO_3)_2$ is a very soluble salt.

1. 2.4×10^{-10} M

2. 3.3×10^{-11} M

3. 2.2×10^{-20} M

4. 5.5×10^{-20} M

5. 5.5×10^{-21} M **correct**

Explanation:
K_{sp} for ZnS $= 1.1 \times 10^{-21}$

$$\text{ZnS} \rightleftharpoons \text{Zn}^{2+} + \text{S}^{2-}$$

$$K_{\text{sp}} = [\text{Zn}^{2+}]\,[\text{S}^{2-}]$$

Since $Zn(NO_3)_2$ is very soluble, there will be an extra 0.20 M Zn^{2+} in solution.

$$1.1 \times 10^{-21} = (x + 0.20)\,(x)$$

We can disregard x in $x + 0.20$ because the K_{sp} is very small, which means ZnS doesn't dissociate much. So the equation now becomes

$$\begin{aligned}1.1 \times 10^{-21} &= (0.20)\,(x) \\ x &= 5.5 \times 10^{-21}\text{ M}\end{aligned}$$

Alternate Solution:

$$K_{\text{sp}}\,\text{ZnS} = [\text{Zn}^{2+}]\,[\text{S}^{2-}] = 1.1 \times 10^{-21}$$

	Zn^{2+} +	H^{2-} ⇌	ZnS
Initial	0.2	–	–
Change	x	x	–
Final	$0.2 + x$	x	–

$$K_{\text{sp}} = (0.2 + x)\,(x) = 1.1 \times 10^{-21}$$

x will be very small compared to 0.2, so $0.2 + x \approx 0.2$, and

$$\begin{aligned}K_{\text{sp}} &= 0.2\,x = 1.1 \times 10^{-21} \\ x &= \frac{1.1 \times 10^{-21}}{0.2} = 5.5 \times 10^{-21}\end{aligned}$$

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008 (part 1 of 2) 10.0 points

Find the Q_{sp} when 5 mL of 0.19 M $K_2CO_3(aq)$

and 1 L of 0.019 M $AgNO_3$(aq) are mixed together. The solubility product of Ag_2CO_3 is 6.2×10^{-12}.

Correct answer: 3.37857×10^{-7}.

Explanation:
$V_{K_2CO_3} = 5$ mL $= 0.005$ L $m_{K_2CO_3} = 0.19$ M
$V_{AGNO_3} = 1$ L $m_{AGNO_3} = 0.019$ M
$V_{tot} = 0.005 \text{ L} + 1 \text{ L} = 1.005$ L

$[Ag^+] = (0.019 \text{ M}) \cdot \dfrac{1 \text{ L}}{1.005 \text{ L}} = 0.0189055$ M

$[CO_3^{2-}] = (0.19 \text{ M}) \cdot \dfrac{0.005 \text{ L}}{1.005 \text{ L}} = 0.000945274$ M

The reaction is

$$Ag_2CO_3(s) \rightleftharpoons 2\,Ag^+(aq) + CO_3^{2-}(aq)$$

$$\begin{aligned} Q_{sp} &= [Ag^+]^2[CO_3^{2-}] \\ &= (0.0189055)^2(0.000945274) \\ &= 3.37857 \times 10^{-7} \end{aligned}$$

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009 (part 2 of 2) 10.0 points

Will a precipitate form?

1. Yes **correct**

2. No

Explanation:
$K_{sp} = 6.2 \times 10^{-12}$

A precipitate will form because $Q_{sp} > K_{sp}$.

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010 10.0 points

What is the value of K_{sp} for Ag_2SO_4 if 5.66 g is soluble in 1.00 L of water?

Correct answer: 2.39381×10^{-5}.

Explanation:
solubility of $Ag_2SO_4 = 5.66$ g/L H_2O

$$\begin{aligned} \text{solubility} &= \left(\frac{5.66 \text{ g } Ag_2SO_4}{\text{L}}\right) \\ &\quad \times \left(\frac{\text{mol } Ag_2SO_4}{311.75 \text{ g } Ag_2SO_4}\right) \\ &= 0.0181556 \text{ mol/L } Ag_2SO_4 \end{aligned}$$

$$Ag_2SO_4(s) \rightleftharpoons 2\,Ag^+(aq) + SO_4^{2-}(aq)$$

$[Ag^+] = 2\,(0.0181556) = 0.0363111$
$[SO_4^{2-}] = 0.0181556$

$$\begin{aligned} K_{sp} &= [Ag^+]^2\,[SO_4^{2-}] \\ &= (0.0363111)^2\,(0.0181556) \\ &= 2.39381 \times 10^{-5} \end{aligned}$$

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011 10.0 points

The term solubility refers to

1. the ability of a substance to gain electrons in solution.

2. the ability of a substance to react with acids or bases in solution.

3. the ability of a substance to form ions in solution.

4. the ability of a substance to gain or lose protons in solution.

5. the ability of a substance to dissolve in solution. **correct**

Explanation:

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012 10.0 points

K_{sp} for iron(III) iodate ($Fe(IO_3)_3$) is 1.0×10^{-14}. We mix two solutions, one containing Fe^{3+} and one containing IO_3^-. At the instant of mixing, $[Fe^{3+}] = 10^{-3}$ M and $[IO_3^-] = 10^{-3}$ M. Which of the following statements is true?

1. A precipitate forms because Q_{sp} is less than K_{sp}.

2. A precipitate forms because Q_{sp} is greater than K_{sp}. **correct**

3. No precipitate forms because Q_{sp} is greater than K_{sp}.

4. None of the statements is true.

5. No precipitate forms because Q_{sp} is less than K_{sp}.

Explanation:

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013 10.0 points

If equal volumes of 0.004 M $Pb(NO_3)_2$(aq) and 0.004 M KI(aq) are mixed, what reaction, if any, occurs? The value of K_{sp} for PbI_2 is 1.4×10^{-8}.

1. KNO_3(s) precipitates.

2. The solution turns purple due to formation of I_2.

3. No reaction occurs. **correct**

4. K_{sp} changes to 9×10^{-9}.

5. PbI_2(s) precipitates.

Explanation:

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014 10.0 points

What is K_{sp} for Ag_3PO_4, if its molar solubility is 2.7×10^{-6} mol/L?

1. 1.4×10^{-21} **correct**

2. 7.3×10^{-12}

3. 5.3×10^{-16}

4. 5.3×10^{-23}

5. 4.8×10^{-22}

6. 2.0×10^{-17}

7. 1.7×10^{-14}

Explanation:
$S = 2.7 \times 10^{-6}$ mol/L

The solubility equilibrium is

$$Ag_3PO_4(s) \rightleftharpoons 3\,Ag^+(aq) + PO_4^{3-}(aq)$$

$[Ag^+] = 3\,S = 8.1 \times 10^{-6}$ mol/L

$[PO_4^{3-}] = S = 2.7 \times 10^{-6}$ mol/L

$$\begin{aligned} K_{sp} &= [Ag^+]^3[PO_4^{3-}] \\ &= \left(8.1 \times 10^{-6}\right)^3 (2.7 \times 10^{-6}) \\ &= 1.43489 \times 10^{-21} \end{aligned}$$

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015 10.0 points

Calculate the solubility product constant for calcium carbonate, given that it has a solubility of 5.3×10^{-5} g/L of water.

1. 1.49×10^{-19}

2. 1.06×10^{-13}

3. 2.81×10^{-13} **correct**

4. 7.89×10^{-26}

5. 3.11×10^{-14}

Explanation:

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016 10.0 points

A saturated solution of CaF_2(s) is found to have a F^- concentration of 4.9×10^{-4} M. What is the value of K_{sp} for CaF_2?

1. 5.88×10^{-17}

2. 3.92×10^{-11}

3. 5.88×10^{-11} **correct**

4. 7.644×10^{-9}

5. 1.176×10^{-8}

Explanation:
$[F^-] = 4.9 \times 10^{-4}$ M

$$CaF_2 \to Ca^{2+} + 2\,F^-$$

$$\begin{aligned} K_{sp} &= \left(\frac{x}{2}\right)(x)^2 = \frac{x^3}{2} \\ &= \frac{\left(4.9 \times 10^{-4}\right)^3}{2} = 5.88 \times 10^{-11}\,. \end{aligned}$$

017 10.0 points

Consider the following data

Compound	K_{sp}
$PbCl_2$	1.7×10^{-5}
$PbBr_2$	3.3×10^{-6}
$Fe(OH)_2$	7.9×10^{-15}
MgF_2	6.4×10^{-9}

Which compound has the greatest molar solubility?

1. $PbCl_2$ **correct**

2. Cannot tell from the information given.

3. $PbBr_2$

4. $Fe(OH)_2$

5. MgF_2

Explanation:

018 10.0 points

Does a precipitate form if 100 mL of 0.00140 M $Ca(NO_3)_2$ and 200 mL of 0.000200 M Na_2SO_4 are mixed?

1. $CaSO_4$ does not precipitate. **correct**

2. $CaSO_4$ precipitates.

Explanation:

$V_{Ca(NO_3)_2} = 0.1$ L $\quad [Ca(NO_3)_2] = 0.0014$ M

$V_{Na_2SO_4} = 0.2$ L $\quad [Na_2SO_4] = 0.0002$ M

$$Ca(NO_3)_2 + Na_2SO_4 \longrightarrow CaSO_4 + 2\,NaNO_3$$

$$CaSO_4(s) \rightleftharpoons Ca^{2+}(aq) + SO_4^{2-}(aq)$$

$$K_{\text{sp}} = [Ca^{2+}]\,[SO_4^{2-}] = 9.1 \times 10^{-6}$$

$$(0.1\text{ L})\,(0.0014\text{ M }Ca^{2+}) = 0.00014\text{ mol}$$

$$(0.2\text{ L})\,(0.0002\text{ M }SO_4^{2-}) = 4 \times 10^{-5}\text{ mol}$$

$$\text{total volume} = 0.1\text{ L} + 0.2\text{ L} = 0.3\text{ L}$$

$$\frac{0.00014\text{ mol }Ca^{2+}}{0.3\text{ L}} = 0.000466667\text{ mol/L}$$

$$\frac{4 \times 10^{-5}\text{ mol }SO_4^{2-}}{0.3\text{ L}} = 0.000133333\text{ mol/L}$$

$$\begin{aligned}[Ca^{2+}]\,[SO_4^{2-}] &= (0.000466667\text{ mol/L}) \\ &\quad \times (0.000133333\text{ mol/L}) \\ &= 6.22222 \times 10^{-8} < K_{sp}\end{aligned}$$

$CaSO_4$ does not precipitate.

019 10.0 points

Determine whether a precipitate will form if 20 mL of 1×10^{-7} M $AgNO_3$ is mixed with 20 mL of 2×10^{-9} M NaCl at 25°C.

1. AgCl precipitates.

2. AgCl does not precipitate. **correct**

Explanation:

$V_{AgNO_3} = 0.02$ L

$[AgNO_3] = 1 \times 10^{-7}$ M

$V_{NaCl} = 0.02$ L

$[NaCl] = 2 \times 10^{-9}$ M

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$$

$$K_{\text{sp}} = [Ag^+]\,[Cl^-] = 1.8 \times 10^{-10}$$

$$(0.02\text{ L})\,(1 \times 10^{-7}\text{ M }Ag^+) = 2 \times 10^{-9}\text{ mol}$$

$$(0.02\text{ L})\,(2 \times 10^{-9}\text{ M }Cl^-) = 4 \times 10^{-11}\text{ mol}$$

$$\text{total volume} = 0.02\text{ L} + 0.02\text{ L} = 0.04\text{ L}$$

$$\frac{2 \times 10^{-9}\text{ mol }Ag^+}{0.04\text{ L}} = 5 \times 10^{-8}\text{ mol/L }Ag^+$$

$$\frac{4 \times 10^{-11}\text{ mol }Cl^-}{0.04\text{ L}} = 1 \times 10^{-9}\text{ mol/L }Cl^-$$

$$\begin{aligned}[Ag^+]\,[Cl^-] &= (5 \times 10^{-8}\text{ mol/L}) \\ &\quad \times (1 \times 10^{-9}\text{ mol/L}) \\ &= 5 \times 10^{-17} < K_{\text{sp}}\end{aligned}$$

AgCl does not precipitate.

020 10.0 points

Pure water is saturated with $PbCl_2$. In this saturated solution

1. $[Pb^{2+}] = [Cl^-]$.

2. $[Pb^{2+}] = 0.5\,[Cl^-]$. **correct**

3. $K_{sp} = [Pb^{2+}]$.

4. $2\,[Cl^-] = [Pb^{2+}]$.

5. $[Pb^{2+}]\,[Cl^-] = K_{sp}$.

Explanation:

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021 10.0 points

If a solution is 1.0×10^{-5} M in $Mn(NO_3)_2$ and 1.5×10^{-3} M in aqueous ammonia, will $Mn(OH)_2$ precipitate?

K_b for $NH_3 = 1.8 \times 10^{-5}$
K_{sp} for $Mn(OH)_2 = 2.0 \times 10^{-13}$

1. yes, because $K_{sp} > Q_{sp}$.

2. no, because $Q_{sp} > K_{sp}$.

3. no, because $K_{sp} > Q_{sp}$.

4. yes, because $Q_{sp} > K_{sp}$. **correct**

Explanation:

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022 10.0 points

Consider the K_{sp} values of the following salts and indicate which of these is least soluble in water. You really don't need to use a calculator to solve this problem.

1. AB_4 $K_{sp} = 1 \times 10^{-25}$ **correct**

2. AB_3 $K_{sp} = 1 \times 10^{-20}$

3. AB_2 $K_{sp} = 1 \times 10^{-15}$

4. AB $K_{sp} = 1 \times 10^{-10}$

Explanation:

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023 10.0 points

The molar solubility of cerium(III) hydroxide ($Ce(OH)_3$) is 5.2×10^{-6} mol/L. What is the K_{sp} of cerium(III) hydroxide?

1. 4.935×10^{-19}

2. 1.23375×10^{-19}

3. 1.97414×10^{-20} **correct**

4. 9.8707×10^{-19}

5. 2.4675×10^{-19}

Explanation:
S = molar solubility
The reaction is

$$Ce(OH)_3(s) \rightleftharpoons Ce^{3+}(aq) + 3\,OH^-(aq)$$

$$\begin{aligned} K_{sp} &= [Ce^{3+}][OH^-]^3 = S\,(3\,S)^3 \\ &= 27\,S^4 = 27(5.2 \times 10^{-6})^4 \\ &= 1.97414 \times 10^{-20} \end{aligned}$$

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024 10.0 points

Rank the following compounds from most soluble to least soluble. Assume that all bonds except the OH are ionic. (You can estimate this ranking without using a calculator.)

Compound	K_{sp}
Bi_2S_3	1.0×10^{-97}
$Fe(OH)_2$	1.6×10^{-14}
PbI_2	2.6×10^{-13}
HgS	1.6×10^{-52}

1. $PbI_2 > Fe(OH)_2 > HgS > Bi_2S_3$

2. $HgS > PbI_2 > Fe(OH)_2 > Bi_2S_3$

3. $Bi_2S_3 > Fe(OH)_2 > HgS > PbI_2$

4. $PbI_2 > Fe(OH)_2 > Bi_2S_3 > HgS$ **correct**

5. $Fe(OH)_2 > PbI_2 > HgS > Bi_2S_3$

Explanation:

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025 10.0 points

What is K_{sp} for AgBr, if its molar solubility is 8.8×10^{-7} mol/L?

1. 0.0053

2. 1.69×10^{-14}

3. 7.744×10^{-13} **correct**

4. 6.9×10^{-9}

5. 1.4×10^{-21}

6. 5.2×10^{-19}

7. 8.281×10^{-17}

Explanation:
$S = 8.8 \times 10^{-7}$ mol/L

The solubility equilibrium is

$$\mathrm{AgBr(s)} \rightleftharpoons \mathrm{Ag^+(aq)} + \mathrm{Br^-(aq)}$$

$[Ag^+] = [Br^-] = S = 8.8 \times 10^{-7}$ mol/L

$$\begin{aligned} K_{sp} &= [Ag^+][Br^-] \\ &= \left(8.8 \times 10^{-7}\right)^2 \\ &= 7.744 \times 10^{-13} \end{aligned}$$

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026 10.0 points

K_{sp} for iron(III) iodate ($Fe(IO_3)_3$) is 1.0×10^{-14}. We mix two solutions, one containing Fe^{3+} and one containing IO_3^-. At the instant of mixing, $[Fe^{3+}] = 10^{-4}$ M and $[IO_3^-] = 10^{-5}$ M. Which of the following statements is true?

1. No precipitate forms because Q_{sp} is less than K_{sp}. **correct**

2. No precipitate forms because Q_{sp} is greater than K_{sp}.

3. A precipitate forms because Q_{sp} is less than K_{sp}.

4. A precipitate forms because Q_{sp} is greater than K_{sp}.

5. None of the statements is true.

Explanation:

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027 10.0 points

The K_{sp} equation for sodium bicarbonate ($NaHCO_3$) should be written as

1. $K_{sp} = [Na^+]\,[H^+]\,[CO_3^{2-}]$. **correct**

2. $K_{sp} = [Na^+]\,[H^+]\,[C^{4+}]\,[O^{2-}]^3$.

3. $K_{sp} = [NaH^{+2}]\,[CO_3^{2-}]$.

4. $K_{sp} = [Na^+]\,[H^+]\,[CO_3^{-2}]^2$.

Explanation: